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BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 23/79)

EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

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ENHANCEMENT OF CHANGES IN BIOELECTRICAL ACTIVITY OF THE BRAIN IN A CONSTANT MAGNETIC FIELD UNDER THE EFFECT OF CORAZOL

Moscow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian No 1, 1979 received by editors 21 Feb 78 pp 21-24

/Article by N. P. Smirnova, presented by P. D. Gorizontov, academician of the USSR Academy of Medical Sciences/

/Text/ The effect of corazol on changes in the background and evoked bioelectrical activity of the cerebral cortex, hypothalamus and cerebellar cortex in a constant magnetic field of an intensity of 500, 1,000 and 4,000 Oe was studied in experiments on rats. After a preliminary administration of corazol in a subconvulsive dose spontaneous rhythms changed sharply in the rats, the amplitude of the evoked potential increased markedly and the number of additional phases in its structure rose. Intensification of the constant magnetic field effect against the background of analeptic corazol action points to the great importance of the level of activation of the central nervous system in the response to the magnetic field effect. (BYULL. EKSPER. BIOL., 1979, No 1, p 22).

Key words: corazol; evoked potentials of the brain; constant magnetic field.

When an animal is placed in a constant magnetic field of quite a high intensity--500 to 1,000 Oe and higher--the background and evoked bioelectrical activity of various brain structures changes markedly. The nature of changes and the results of functional loads made it possible to assume that during the constant magnetic field effect excitation processes predominate in the central nervous structures. The object of this study was to clarify the possibilities of modifying the constant magnetic field effect by changing the functional state of the central nervous system.

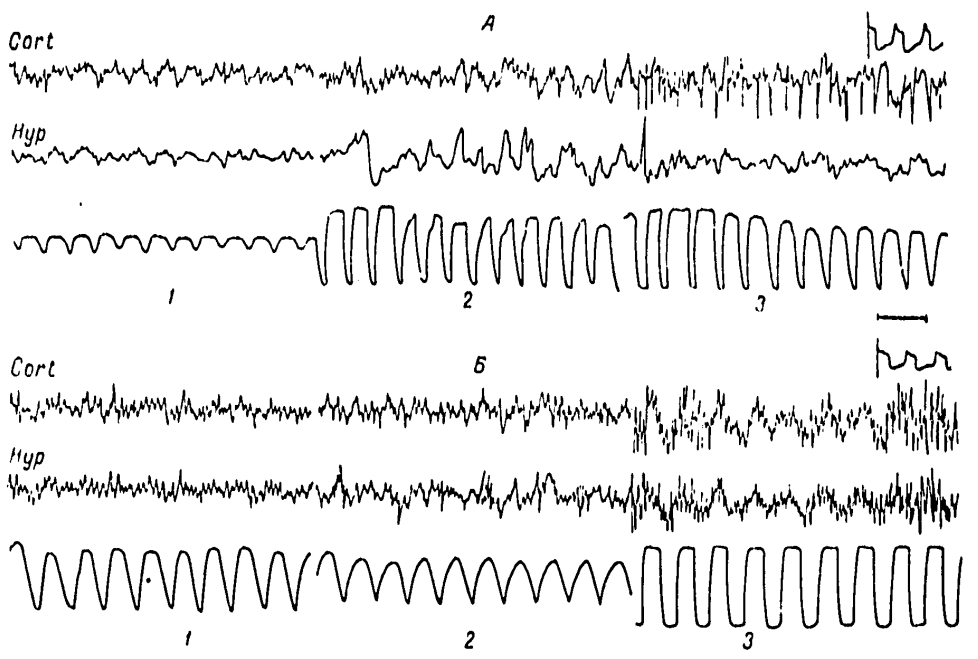

Fig. 1. The Effect of Corazol on the Spontaneous Bioelectrical Activity of the Cerebral Cortex and Hypothalamus in Anesthesized Intact (A) and Alert Rats in a Constant Magnetic Field of an Intensity of 4,000 Oe (Б).

A: 1--before the administration, 2--3 min after, 3--30 min after the administration of corazol (30 mg/kg); Б: 1--before the effect, 2--a constant magnetic field of an intensity of 4,000 Oe, 3--in a constant magnetic field of an intensity of 4,000 Oe 5 min after the administration of corazol (30 mg/kg). Calibration of amplification, 50 μV and of time, 1 s.

Method of investigation. In 23 white rats anesthesized with Nembutal (40 mg/kg, intraperitoneally) before, during and after the general effect of a constant magnetic field of an intensity of 500, 1,000 and 3,000 Oe evoked potentials were tapped from the sensomotor region of the cerebral cortex, anteromedian sections of the hypothalamus and the anterior vermix cortex. For a unipolar tapping of evoked potentials from cortical sections silver electrodes were used, and from the hypothalamus, manganin wire electrodes. The sciatic nerve was stimulated with square current pulses of 0.5 ms duration with an intensity equal to the double threshold intensity. Corazol was administered intraperitoneally in a dose of 20 mg/kg in 1% solution and 5 to

7 min after the administration the recording of evoked potentials was repeated before and during the constant magnetic field effect. At every moment of the experiment 10 responses to pulses following at a 5 s interval were recorded in a rat. When the results were processed, the form and amplitude of evoked potentials measured from peak to peak were taken into consideration and the mean value at every moment of recording was calculated for each rat.

The effect of corazol (20 to 40 mg/kg) on the background rhythms of the brain and their changes in a constant magnetic field of an intensity of 4,000 Oe were investigated in 13 rats. These experiments were partially conducted on alert rats dressed, for the purpose of reducing motor disturbances, in special small caftans. The electrograms of the cerebral cortex and the hypothalamus (unipolarly) and respiration were recorded on an electroencephalograph. A vertically directed constant magnetic field was created by electromagnet SP-15 A, in whose 100X300X400 mm gap a rat was placed (see /3/).

Results of investigation. The analeptic effect of a subconvulsive corazol dose (20 to 30 mg/kg) is manifested in rats 2 to 3 min after intraperitoneal administration. Some motor restlessness and increase in the rate and intensification of respiration are observed in alert rats. In rats under light Nembutal anesthesia corazol administration leads to awakening. With deep anesthesia there is no visible awakening. However, changes in respiration and an increased sensitivity to external stimuli are noticeable and sleep becomes more superficial. The external manifestations of the analeptic effect of corazol are accompanied by characteristic changes in the background bioelectrical activity of the brain /1, 2, 6 and 7/, which can be pronounced to a greater degree in the cerebral cortex than in the hypothalamus (fig. 1, A). Changes in the evoked bioelectrical activity during the administration of corazol to rats anesthesized with Nembutal are often expressed in a decrease in the amplitude of evoked potentials. On the average, the amplitude of evoked potentials of the cerebral cortex dropped to 84.7±5.7%, of the hypothalamus, to 19.9±2.2% and of the cerebellar cortex, to 91.4±4.9% of the initial amplitude.

The constant magnetic field effect with regard to the background and evoked bioelectrical activity of the brain increases markedly against the background of analeptic corazol action. According to the data previously obtained by us, in alert rabbits the changes in background rhythms during the effect of a constant magnetic field of a high intensity consist in the appearance on the electrograms of various brain sections of bursts of synchronized high-voltage discharges, which with an increase in the field intensity or a high individual sensitivity of animals can change into a regular activity synchronized primarily in the α-β_1 frequency rhythm /5/. In figure 1, Б, it can be seen that in the alert rat the effect of a constant magnetic field of an intensity of 4,000 Oe also caused an increase in the rate of the biocurrents of the cerebral cortex and the appearance of bursts of synchronized discharges in the hypothalamus. After the administration of corazol (30 mg/kg) on the electrograms of both sections frequent activity increased in amplitude and became more regular.

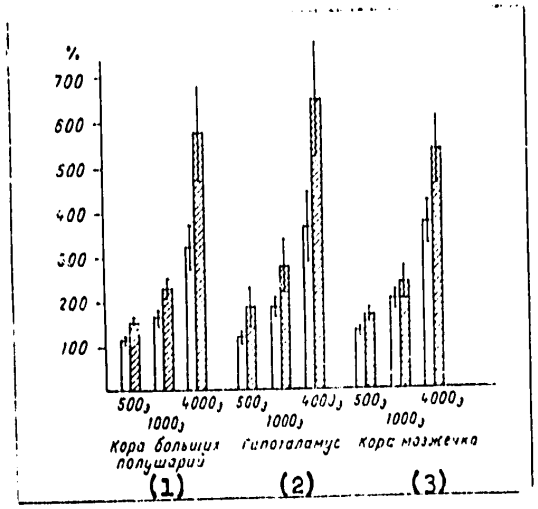

Fig. 2. The Effect of a Constant Magnetic Field on the Evoked Activity of the Brain After the Administration of Corazol (20 mg/kg)

Y-axis--increase in the amplitude of evoked potentials (in % of the initial amplitude); X-axis--intensity of a constant magnetic field, Oe. Light columns--before the administration and cross-hatched columns--after the administration of corazol.

Key:
1. Cerebral cortex
2. Hypothalamus
3. Cerebellar cortex

The changes in evoked activity in a constant magnetic field were described for the cerebral cortex and the cerebellar cortex of rats anesthesized with Nembutal. They lie in an increase in the amplitude of the evoked potential and in the appearance of additional phases in its structure /3/. We also detected similar changes in other brain sections, in particular in the hypothalamus. In a constant magnetic field after a preliminary administration of corazol the amplitude of the evoked potential increases more markedly in the highest-voltage part of the potential. This is clearly seen from the averages (fig. 2) for all the investigated brain structures and with the three levels of intensity of the magnetic field. For the cerebral cortex intensification of the effect of a constant magnetic field evaluated according to the degree of increase in the amplitude of the evoked potential is significant ($P<0.05$). In all the structures the effect of a constant magnetic field of an intensity of 500 Oe after the administration of corazol becomes equal to such an effect in a constant magnetic field of an intensity of Oe in intact rats. Corazol intensifies the effect of appearance of multicomponent potentials in a constant magnetic field. The number of phases in

the structure of evoked potentials in all the three studied brain sections, on the average, increases from 1.9 during the initial period to 2.5 in a constant magnetic field of an intensity of 500 Oe, to 3.9 with an intensity of 1,000 Oe and to 5.5 with an intensity of 4,000 Oe. In rats, which received corazol in advance, the corresponding indicators were 1.9, 3.0, 4.8 and 6.7.

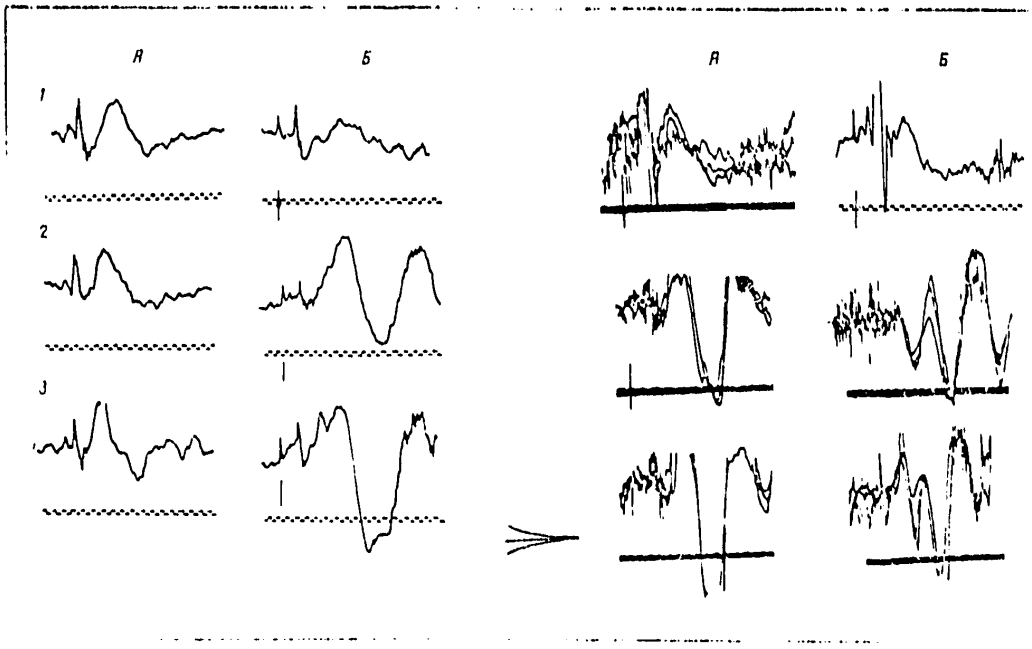

Fig. 3. The Effect of Corazol on a Change in the Evoked Potentials of the Cerebellar Cortex (to the Left) and Hypothalamus (to the Right) in a Constant Magnetic Field.

А--before the administration of corazol, Б--after the administration of corazol (20 mg/kg); 1--before the effect of a constant magnetic field, 2--in a constant magnetic field of an intensity of 500 Oe, 3--in a constant magnetic field of an intensity of 1,000 Oe. Calibration of amplification, 50 μV and of time, 10 ms.

Variants in the very effect of a constant magnetic field and its modifications under the action of corazol were noted in some animals. In the experiment presented in figure 3 (to the left) before the administration of corazol there were hardly any changes in the evoked potentials of the cerebellar cortex in a constant magnetic field of an intensity of 500 Oe and the changes in a constant magnetic field of an intensity of 1,000 Oe were not sharp--the amplitude of evoked potentials increased slightly and a small additional negative phase appeared. The administration of corazol brought

about a decrease in the amplitude of the initial evoked potential, but in a constant magnetic field of an intensity of 500 and 1,000 Oe it increased sharply, especially the amplitude of an additional slow oscillation. In another rat (fig. 3, to the right) the evoked potential of the hypothalamus (lateral hypothalamic nucleus) did not change markedly after the administration of corazol and the changes in a constant magnetic field were expressed mainly in an increase in the number of additional phases.

Thus, a preliminary administration of corazol in subconvulsive doses brings about a marked intensification in the changes of bioelectrical processes in the brain of rats during the effect of a constant magnetic field. There are also data on an intensification of EEG changes in rabbits subjected to the effect of a constant magnetic field on the head after the administration of caffeine /4/. Apparently, intensification of the effects of a constant magnetic field against the background of the action of analeptics can point to the great importance of the level of activation of the central nervous system in the sensitivity of animals to the magnetic field effect.

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SOME CHARACTERISTICS OF RETICULAR INFLUENCES ON THE EVOKED ACTIVITY OF THE CEREBELLUM UNDER THE EFFECT OF A CONSTANT MAGNETIC FIELD

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI in Russian No 1, 1979 received 24 Jan 78 pp 196-199

/Article by L. D. Klimovskaya, Moscow/

/Text/ A change in the spontaneous and evoked bioelectric activity of the brain is one of the natural reactions of the central nervous system to the effect of constant magnetic fields /2-6/. During the stay of animals in a constant magnetic field of a high intensity (1,000 Oe and more) the amplitude of evoked potentials increases and the form becomes more complicated as a result of the appearance of additional components. Shifts are of a generalized nature and are synonymous in various sections of the brain /2/. In connection with this there is the question of the effect of a constant magnetic field on the state of intracentral mechanisms responsible for the regulation of the sensory inflow and the level of excitability of afferent brain systems. As is well known, the integrative activity of the reticular formation of the brain stem plays an important role in the performance of these functions. We showed earlier that the stimulation of the mesencephalic reticular formation evokes a persistent inhibition of the somatosensory evoked potentials of the cerebellum in rats /1/. In this study this phenomenon was utilized for an investigation of the effect of the mesencephalic reticular formation on the state of afferent brain systems in animals subjected to the effect of a constant magnetic field of a high intensity.

This study was conducted on 52 noninbred white rats under a light Nembutal anesthesia (40 mg/kg intraperitoneally). In response to the stimulation of the sciatic nerve by single pulses (0.5 msec) evoked potentials were tapped unipolarly from the cortex of the anterior vermis cerebelli by means of implanted silver electrodes and recorded on an oscillograph before, during and after the stimulation of the mesencephalic reticular formation, which was effected through bipolar nichrome electrodes by rectangular pulses (0.1 msec) with a frequency of 300 per sec with a voltage of 10 V during 30 sec. As in our previous studies, the SP-15A electromagnet was utilized /2, 3/. In the basic series of experiments rats were subjected to a single total effect of

a magnetic field of an intensity of 4,000 Oe during 15 min. The effects of stimulation of the mesencephalic reticular formation were investigated in every rat before the effect, during the sixth minute of stay in a constant magnetic field and 1 min after the disconnection of the electromagnet. Repeated stimulations of the reticular formation at the same intervals were effected in the control series.

The electric responses of the cerebellar cortex to the stimulation of the sciatic nerve in intact rats represented primarily two-phase potentials of a relatively low amplitude (181.8±11.37 μV from peak to peak). The high-frequency stimulation of the reticular formation in 97% of the rats led to an inhibition of the evoked activity of the cerebellum. An increase in the amplitude of evoked potentials in the process of stimulation of the mesencephalic reticular formation could be observed only in isolated animals. Histological control showed that in these cases the tips of stimulating electrodes were in the sections of the midbrain, whose stimulation in other animals produced a distinct inhibitory effect. When rats stayed in a magnetic field of an intensity of 4,000 Oe, evoked potentials, as a rule, acquired a multiphase form, their amplitude increased and in the highest-voltage part sometimes reached 500 to 800 μV. Along with this changes in reticular effects were detected. As follows from the average data (table), during the effect of a constant magnetic field statistically significant shifts attesting to a decrease in the intensity of inhibitory effects of the stimulation of the reticular formation on the evoked activity of the cerebellum are observed. After the effect ceases, restoration occurs. No changes in the effects of repeated stimulations of the reticular formation at the same intervals in control experiments were detected. For the interpretation of the data obtained of great importance is the fact that the appearance of signs of alleviation of the evoked activity of the cerebellum during the stimulation of the reticular formation, signs pronounced to one degree or another, was noted in approximately one-third of the rats (in 13 out of 40) subjected to the effect of a constant magnetic field. As can be seen from figure 1, the stimulation of the mesencephalic reticular formation before the effect of a magnetic field produced a marked decrease in the amplitude of the evoked potentials of the cerebellum. The effect of a magnetic field led to the appearance of one additional component in the structure of evoked potentials. During the stimulation of the reticular formation against the background of the effect of a constant magnetic field the amplitude of the basic component did not change, but increased additionally. A complete distortion of the effect of stimulation of the reticular formation under the effect of a constant magnetic field could be observed in some experiments. An example of such an experiment is presented in figure 2, I. When a rat stayed in a constant magnetic field, a considerable increase in the amplitude and complication of the form of evoked potentials of the cerebellum was observed and the stimulation of the reticular formation, instead of inhibition, began to produce a pronounced alleviation of the evoked activity. It should be noted that an apparent correlation between the nature of change in the evoked activity of the cerebellum and the effects of stimulation of the reticular formation under the conditions of the effect of a

magnetic field was not detected. In the second case (II) presented in figure 2 the effect of a magnetic field, as in the first case, led to a sharp exaltation of cerebellar responses. However, the inhibitory effects of the reticular formation were retained completely. At the same time, elimination of the inhibitory effect of stimulation of the mesencephalic reticular formation under the effect of a constant magnetic field could also be observed when the changes in the nature of the evoked activity of the cerebellum were not very significant (figure 1).

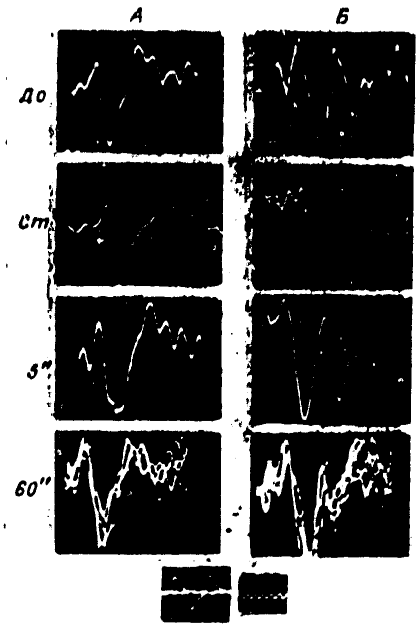

Figure 1. Elimination of the Inhibitory Effects of Stimulation of the Mesencephalic Reticular Formation on the Evoked Potentials of the Cerebellum Under the Effect of a Constant Magnetic Field. А--Before the Effect; Б--During the Stay of a Rat in a Magnetic Field of 4,000 Oe; До--Before Stimulation; СТ--During Stimulation; Figures--Time After Stimulation, sec. Frames Below--Calibration of Amplification, 50 μV and of time, 10 msec.

The Effect of a Constant Magnetic Field of an Intensity of 4,000 Oe on Changes in the Evoked Potentials of the Cerebellum Occurring During the Stimulation of the Mesencephalic Reticular Formation

Series	Number of rats	Amplitude of Evoked Potentials During Stimulation, % of Initial		
		First stimulation	Second stimulation	Third stimulation
Control	12	44.5±11.5	43.6±9.0	42.6±11.3
		Before the effect	In the magnetic field	After the effect
Basic	40	43.9±4.8	71.1±8.7	40.1±8.5

(P<0.05)

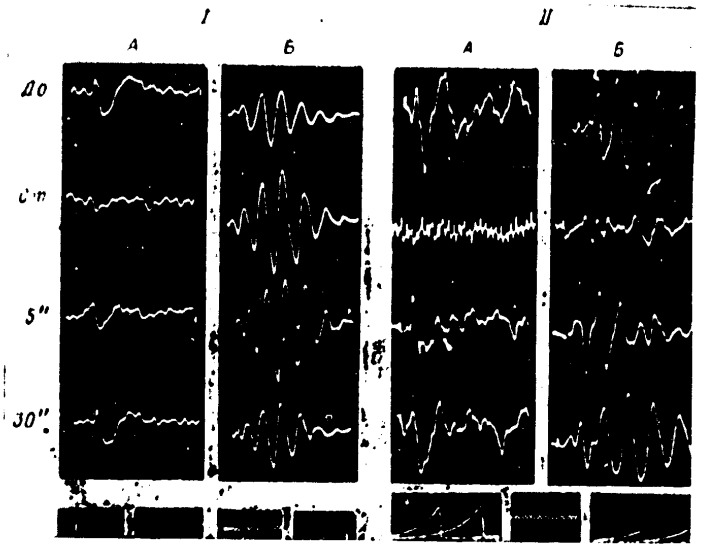

Figure 2. Appearance of Alleviating (I) and Preservation of Inhibitory (II) Effects of Stimulation of the Mesencephalic Reticular Formation on the Evoked Potentials of the Cerebellum Under the Effect of a Constant Magnetic Field. Designations as in Figure 1.

Thus, the data obtained make it possible to conclude that the effect of a constant magnetic field leads to the weakening of the inhibitory and intensification of the alleviating effects of the mesencephalic reticular formation on the activity of the afferent systems of the cerebellum. According to existing concepts, reticular effects on the generation of electric responses play an important role in the mechanisms of perception, ensuring the necessary level of activity of afferent brain systems according to the current

needs of the body. When these processes are disturbed under the conditions of effect of a magnetic field of a high intensity, the perceiving function of the brain can suffer considerably.

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WORK WITHIN CEMA IN THE FIELD OF MEASUREMENTS OF IONIZING RADIATION

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 1, 1979 pp 25-27

/Article by M. F. Yudin and F. M. Karavayev (USSR), K. Zhdanski (Hungarian People's Republic), Z. Referovskiy and M. Derezhinski (Polish People's Republic), G. Rothe (GDR) and L. Kokta (CSSR)/

/Text/ During the period following the publication /1/ work on ensuring the unity and correctness of measurements of ionizing radiation in CEMA countries continued to develop successfully. In 1974-1976 the CEMA Permanent Commission on Standardization approved the following sets of means of measurements as CEMA standards:

the standard of a unit of activity of radionuclides within the national standards of the Hungarian People's Republic, GDR, USSR and CSSR, for the range below 1 MBq, and within the UEA-4 and UEA-5 standard apparatus of the USSR state primary standard, for the range from 1 MBq and higher;

the standard of a unit of exposure dose of photon radiation within the national standards of the Hungarian People's Republic, GDR, Polish People's Republic and USSR;

the standard of a unit of absorbed dose of beta-radiation within the national standards of the GDR and USSR;

the standard of a unit of absorbed dose of neutron radiation within the USSR state primary standard;

the standard of a unit of neutron radiation flux within the USSR state primary standard;

the standard of a unit of density of neutron radiation flux within the USSR state primary standard;

the standard of a unit of power of absorbed dose of photon radiation (with 1.25 MeV energy) within the national standards of the GDR and USSR.

Instead of the check schemes previously in effect new check schemes for the means of measurements of the activity of radionuclides, exposure dose of photon radiation and neutron radiation flux and flux density were approved in 1978. The rules of keeping and applying CEMA standards envisage a periodic comparison of the national standards forming part of CEMA standards. Other CEMA members, which have the appropriate means of measurements, can join these comparisons.

Comparisons of the standards of a unit of activity of radionuclides were made in 1974 with the participation of specialists from the following laboratories, keepers of the national standards forming part of CEMA standards: of the State Administration of Metrology (OMKh) of the Hungarian People's Republic (K. Zhdanski and A. Sereni), of the Administration for Standardization, Metrology and Testing of Goods (ASMV) of the GDR (G. Rothe and H. Greipner), of the All-Union Scientific Research Institute of Metrology imeni D. I. Mendeleyev (VNIIM) of the USSR (F. M. Karavayev, A. Ye. Kochin and A. F. Drichko) and of the Institute for the Production, Application and Investigation of Radioisotopes (UVVVR) of the CSSR (L. Kokta and Ya. Sderadichka). Representatives of the laboratory of the Polish Committee on Standardization and Measures (PKNiM) (M. Derezhinski and N. Paż) participated in the comparison of the standards of a unit of activity of γ-emitting radionuclides.

The working standards of VNIIM--sources of γ-radiation ^{137}Cs No 396 and No 818--were used for a comparison of the standards of a unit of activity of γ-emitting radionuclides. The activity of ^{137}Cs in these sources was measured on the UEA-4 standard apparatus of the USSR state primary standard /2, 3/ by the ionizing method. In ASMV, OMKh, UVVVR and PKNiM the activity of ^{137}Cs in the sources of VNIIM was measured by the relative method by comparing them with similar internal sources or with ampoules with ^{137}Cs solution by means of ionization chambers (in UVVVR). The comparison results are presented in table 1, where random and systematic errors are summed up (for fiducial probability 0.99) according to the method of the International Commission on Radiological Units and Measurements /4/. When the activity of ^{137}Cs was determined, the presence of ^{134}Cs admixture in sources, as well as self-absorption and absorption in ampoule walls, were taken into account.

From the data presented it follows that the deviations of the values of activity of ^{137}Cs in sources measured in OMKh, ASMV, VNIIM and UVVVR from the mean values amounting to $4{,}196 \cdot 10^9$ and $3.434 \cdot 10^8$ Bq do not exceed 1%, that is, much less than the evaluated errors of measured values. This means that the systematic error of measurements by all the participants in the comparison is greatly overstated. Thus, the comparison made permits a significant reduction in the error of measurements of the activity of γ-emitting radionuclides.

The comparison of the standards of a unit of activity of β-emitting radionuclides was made by means of ^{137}Cs and $^{90}Sr+^{90}Y$ solutions. The measurements were made by the 4πβ-counting method on the standard apparatus of member countries. For the determination of corrections for self-absorption

the indicator extrapolation method was used in OMKh, ASMV and UVVVR. The results of comparisons are presented in table 2, where the total error is determined by the method of the International Commission on Radiological Units and Measurements /4/ for fiducial probability 0.99.

Table 1.

(1) Лаборатория	(2) Источник № 396		(2) Источник № 818	
	Активность ^{137}Cs, 10^9 Бк (3)	Относительная погрешность, % (4)	Активность ^{137}Cs, 10^9 Бк (3)	Относительная погрешность, % (4)
ОМХ (5)	4,231	3,2	3,467	2,5
АСМВ (6)	4,181	2,6	3,422	2,7
ВНИИМ (7)	4,155	6,3	3,401	6,3
УНИИР (8)	4,211	4,3	3,437	4,3
ПКНиМ (9)	4,059	7,0	3,286	7,0

Key:
1. Laboratory
2. Source
3. ^{137}Cs activity, 10^9 Bq
4. Relative error
5. OMKh
6. ASMV
7. VNIIM
8. UVVVR
9. PKNiM

Table 2

(1) Лаборатория	Раствор ^{137}Cs (2)		Раствор ^{90}Sr+^{90}Y (2)	
	Удельная активность ^{137}Cs, кБк/г (3)	Относительная погрешность, % (4)	Удельная активность ^{90}Sr+^{90}Y, кБк/г (3)	Относительная погрешность, % (4)
ОМХ (5)	185,5	1,40	119,2	0,95
АСМВ (6)	186,0	1,57	120,2	0,36
ВНИИМ (7)	183,8	1,30	120,5	0,55
УНИИР (8)	185,3	1,40	120,4	0,46
	185,6	1,40		
Среднее (9)	185,3		120,1	

Key:
1. Laboratory
2. Solution
3. Specific activity of ^{137}Cs, kBq/g
4. Relative error
5. OMKh
6. ASMV
7. VNIIM
8. UVVVR
9. Average

The results of comparisons showed that the reproduction of a unit of activity of β-emitting radionuclides by the national standards of the Hungarian People's Republic, GDR, SSSR and CSSR (by the CEMA standard) is made correctly without significant unconsidered systematic errors. The deviations of the results obtained on individual standards from the mean values do not exceed the limits of evaluated errors.

The work performed according to the plan of the CEMA Permanent Commission on Standardization in 1971-1973 contributes to ensuring the unity of measurements and to increasing their accuracy. This work proposes the most efficient methods of determining partial correction coefficients taking into account self-absorption and absorption in ampoule walls (for γ-radiation sources), change in the efficiency of a detector during a change in photon energy, attenuation and absorption of photons in the walls of ionization chambers, as well as determinations of coefficients taken into consideration during the measurement of activity by the $4\pi\beta\gamma$-coincidence method. As a result of an analysis of the data published in the literature the most accurate and reliable values of universal constants (photon energy, maximum and average energy of β-particles, number of photons and β-particles per act of decay, half-decay period and so forth) were selected and recommended for radionuclides most often used in metrological practice.

The automated measuring apparatus developed in OMKh and UVVVR are of great importance. They ensure the identification and measurement of the activity of admixture radionuclides in radioactive sources of radiation and in radioactive samples. A many-sided comparison of the standards of a unit of activity of α-emitting radionuclides by means of ^{241}Am solutions is planned for 1979.

Comparisons of the standards of a unit of exposure dose of X-radiation with 10 to 250 keV generated voltage belonging to CEMA members were made in 1974-1975. The comparisons were made separately over the ranges 10 to 60 keV and 60 to 250 keV with the participation of OMKh of the Hungarian People's Republic (K. Zhdanski and I. Khizo); ASMV of the GDR (G. Rothe and K. Helmshtedner); PKNiM of the Polish People's Republic (Z. Referovski, M. Derezhinski and N. Paz); VNIIM (V. I. Fominykh, I. A. Uryayev, G. P. Ostromukhova and R. F. Kononova); only over the range 10 to 60 keV, ChSMU /expansion unknown/ and the Center of Radiation Hygiene (TsGI) of the CSSR (A. Drabek and O. Kodl).

Comparisons of the primary standards of a unit of exposure dose of X-radiation over the range 10 to 60 keV were made by means of a free-air standard comparison chamber belonging to VNIIM and forming part of the USSR state standard of a unit of exposure dose. This chamber and the electrical measuring device of VNIIM with a control radioactive source of $^{90}Sr+^{90}Y$ were transported to each of the participating countries.

Free-air ionization chambers of the plane-parallel type were used in all national standards. The comparison of standards boiled down to the determination of the constant of the comparison chamber of VNIIM by means of the national standards of CEMA members. The substitution method was used for this. Chambers were placed in the beam of X-radiation so that the planes of the limiting diaphragms to which the measured values of exposure doses pertained might be at the same distance from the anode of the X-ray tube.

Table 3 presents the relationships of the results of measurement of the constant of the comparison chamber to the mean arithmetical value of the constant for the CEMA standard.

Table 3

Режим излучения, кВ/мм Al (1)	(2)	(3)	(4)	(5)	(6)	
					ЧССР,	
					ЧСМУ (7)	ЦИМ (8)
10/0,026	–	0,994	–	1,006	0,997	1,007
30/0,18	1,001	0,997	1,003	1,000	0,984	0,989
		0,995				
50/1,0	1,000	0,998	1,002	1,003	1,006	1,009
60/2,3	0,999	0,993	1,001	1,004	0,989	1,005

Key:
1. Radiation conditions, kV/mm Al
2. Hungarian People's Republic, OMKh
3. GDR, ASMV
4. Polish People's Republic, PKNiM
5. USSR, VNIIM
6. CSSR
7. ChSMU
8. TsGI

From the data of table 3 it follows that the amount of the unit of exposure dose of CEMA members differs from the amount of the unit reproduced by the CEMA standard by no more than 0.7%. On the basis of an analysis of results it was established that the CEMA standard in the indicated energy region is at the present scientific and technical level. During subsequent comparisons, in order to increase the accuracy, it is recommended that a free-air chamber be used, determining by absolute methods the value of the rate of exposure dose in every country by means of the national standard and comparison chamber, not the constant of the chamber, as envisaged in MS15-72 recommendations.

During comparisons over the range 60 to 250 keV free-air chambers of the plane parallel type (OMKh, ASMV and PKNiM) and a cylindrical chamber (VNIIM) were used in all standard apparatus. The cavity chambers of OMKh, ASMV and PKNiM were used as comparison standards. Chamber cavities were connected with the atmosphere. The method of comparisons was similar to that for the 10 to 60 keV energy range.

Table 4 presents the relationships of the results of measurements of the constants of comparison chambers to the mean arithmetical value of the constant for the CEMA standard.

Table 4

Камера (1)	Режим излучения, кВ/мм Cu (2)	ВНР, ОМХ (3)	(4)	(5)	(6)
ОМХ (7)	100/0,15	0,996	1,003	0,999	--
	135/0,50	0,999	0,996	0,995	1,009
	180/1,0	0,995	1,000	1,004	1,001
	220/2,0	--	0,991	0,995	1,010
	250/2,5	1,001	0,995	--	--
АСМВ (8)	100/0,15	0,997	1,007	0,996	--
	135/0,50	1,001	0,997	0,991	1,008
	180/1,0	1,004	1,002	0,993	1,002
	220/2,0	--	1,003	0,995	1,001
	250/2,5	1,001	0,999	--	--
ПКНиМ (9)	100/0,15	0,989	1,006	1,004	--
	135/0,50	0,997	1,005	0,998	--
	180/1,0	1,000	0,995	1,005	--

Key:

1. Chamber
2. Radiation conditions, kV/mm Cu
3. Hungarian People's Republic, OMKh
4. GDR, ASMV
5. Polish People's Republic, PKNiM
6. USSR, VNIIM
7. OMKh
8. ASMV
9. PKNiM

From an analysis of the results of comparisons it follows that the amount of the unit of exposure dose reproduced by the national standards of CEMA members differs from the amount of the unit reproduced by the CEMA standard by no more than 1%, which lies within the error of measurements with national standards. Thus, the CEMA standard over the energy range 60 to 250 keV is also at the present scientific and technical level.

The research conducted enabled the CEMA countries that took part in the comparisons to obtain useful information on the methods and means used in every country, to unify the determination of some correction coefficients introduced into the results of measurements and to increase the reliability of reproduction of a unit of exposure dose of X-radiation over the 10 to 250 keV energy range.

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